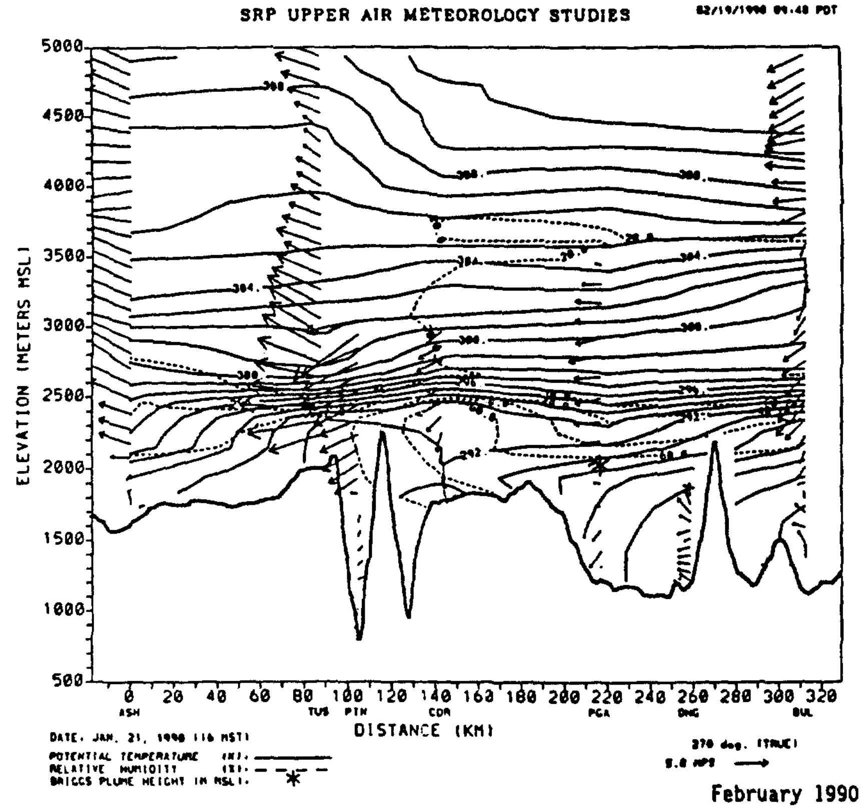
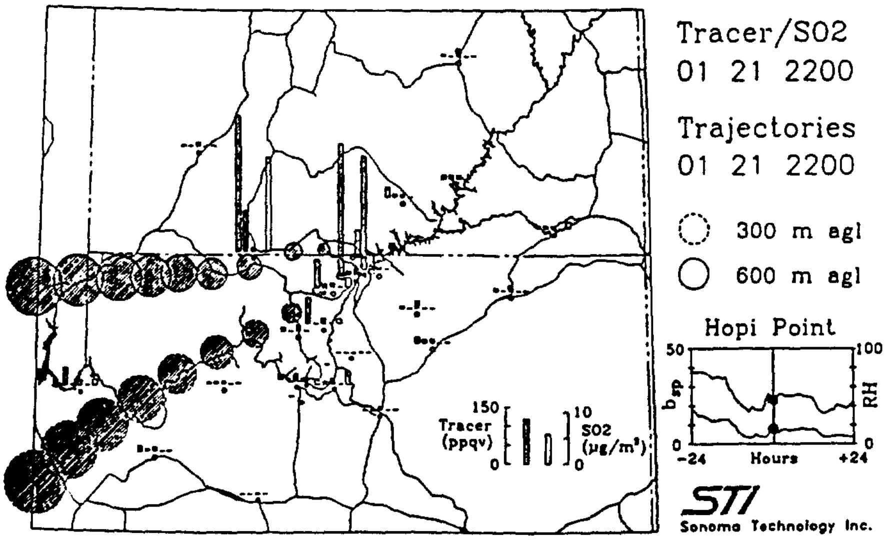


Figure 3 Isentropic cross-section for 1600 MST January 21, 1990. Solid lines are isentropes, dashed lines are isopleths of constant relative humidity, and vectors indicate wind speed and direction (north to top of figure, east to right of figure). The heavy solid line represents terrain elevations along the ground path of the cross-section. Briggs plume height estimate of the altitude of the NGS plume is indicated by a star above Page.



March 1991

Figure 5 Example of a single frame of the computer animation, showing the locations of the 300 m agl and 600 m agl streak lines and Hopi Point b_{sp} and relative humidity at 2200 MST January 21, 1990; tracer and SO_2 concentrations shown were collected from 2200 MST January 21 until 0200 MST January 22, 1990.

APPENDIX F

WIND PROFILER OBSERVATIONS WITHIN CALIFORNIA'S SAN JOAQUIN VALLEY

By:

James M. Wilczak, Robert J. Zamora, and David C. Welsh
NOAA/Wave Propagation Laboratory

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WIND PROFILER OBSERVATIONS WITHIN CALIFORNIA'S SAN JOAQUIN VALLEY

2.6

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Boulder, CO 80303

1. INTRODUCTION

During the summer of 1990, an array of seven 915 MHz lower tropospheric wind profilers was deployed in central California as part of the San Joaquin Valley Air Quality Study (SJVAQS). The array consisted of 5 profilers deployed in the southern portion of the San Joaquin Valley (at Modesto, El Nido, Raisin City, Reedley and Corcoran), with an approximate horizontal spacing of 50 km (Fig. 1). In addition, two profilers (Hollister, Carrizo) were deployed in the higher elevations of California's coastal mountain range. The profilers were operated in two simultaneous modes: a low resolution mode, consisting of a 400 m pulse width sampled every 200 m, and a high resolution 60 m pulse width sampled every 60 m. These provided winds from a minimum height of 150 m AGL to ~4 km AGL. Additional details on the radar wind profilers can be found in Ecklund et al., 1988.

During the summer months, flow in the lower troposphere in southern California is only weakly forced by transient synoptic features. Instead, a quasi-stationary synoptic regime is present that is strongly influenced by a climatological surface high pressure over the north Pacific, resulting in large-scale northwest surface winds. Similarly, ridging over the intermountain and midwest states results in a southerly to southwesterly flow at 700 mb. The predominant flow features during these months are topographically forced responses to this large-scale flow, and local circulations resulting from surface diabatic processes. Principal features of the topography in this area (Fig. 1) are to the east the Sierra Nevada mountain range, with an average height of ~3000 m MSL; the San Joaquin Valley, a flat, northwest-southeast oriented valley, more than 500 km in length; and to the west, the Coast Range, which has an average height of ~1000 m MSL. Strong channeling of marine air into the San Joaquin Valley often occurs in the San Francisco Bay area, where a break in the Coast Range exists.

The diurnally varying mean flow for the month of August, 1990 is characterized at each profiler site through 24 h composites of time-height wind profiles. These composites reveal several distinct boundary layer features, including a pronounced nocturnal low-level jet, a topographically forced mesoscale vortex, and strong diurnal oscillations at each profiler site. Spectra of the profiler data demonstrate a frequency dependence consistent with both stratified two-dimensional turbulence and with a saturated gravity-wave spectrum.

2. ENSEMBLE DIURNAL WINDS

Averaged diurnal time-height cross-sections of the profiler winds at Modesto (see Fig. 1) are shown in Fig. 2a for the month of August, 1990. Notable features are the dominance of northwesterly winds in the lowest several kilometers, resulting in part from the channeling effect of the mountain ranges on either side of the San Joaquin Valley. During the nighttime hours a low-level jet forms with wind speeds reaching a maximum of 9.3 m s^{-1} at a height of 350 m MSL. During the mid-day hours wind speeds in the lowest 2.0 km reach a minimum, and become more westerly in direction. This zone of westerly flow tends to persist longer at higher elevations, with the northwesterly flow reforming first near ground level. Throughout the diurnal cycle the winds above the westerlies and northwesterlies back to southerly in a thin transition layer. The interface between these two distinct wind regimes has a very pronounced diurnal variation, with the low level northwesterlies deepest at midnight (~3.0 km MSL) and shallowest near noon (~1.5 km MSL). We interpret the formation of the mid-day low-level westerlies and the descent of the interface to the presence of surface heating on the slopes of the Sierras. This results in a westerly flow that is drawn towards the Sierras, and subsequent subsidence over the valley.

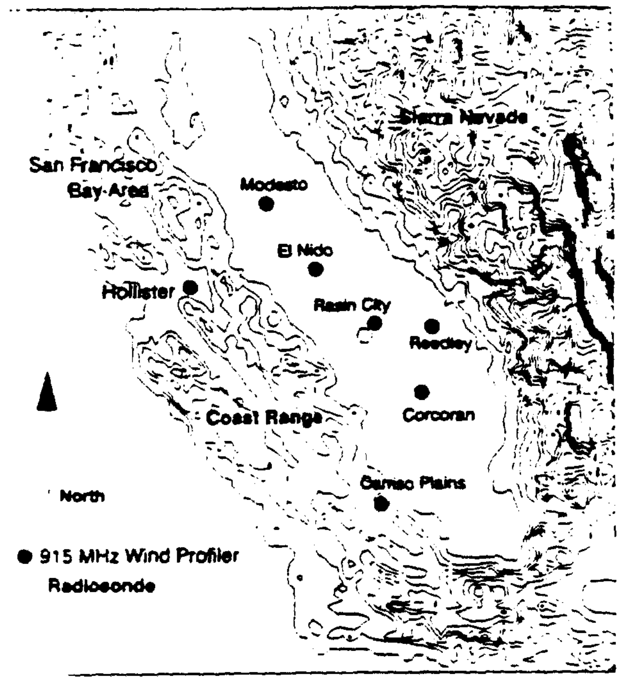

Fig. 1 Topographic map of central California, with a contour interval of 300 m, starting at 100 m MSL. Principal features are the Coast Range and Sierra Nevada mountains, between which lies the San Joaquin Valley.

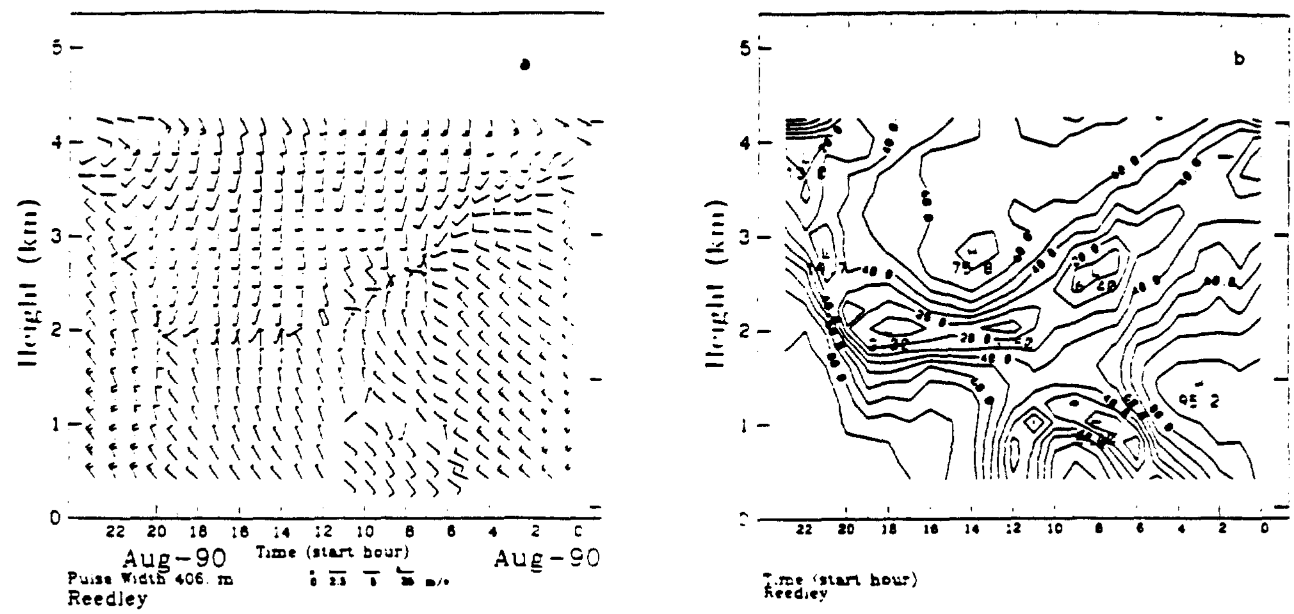

Fig. 4 As in Fig. 2, except for the Reedley profiler data.

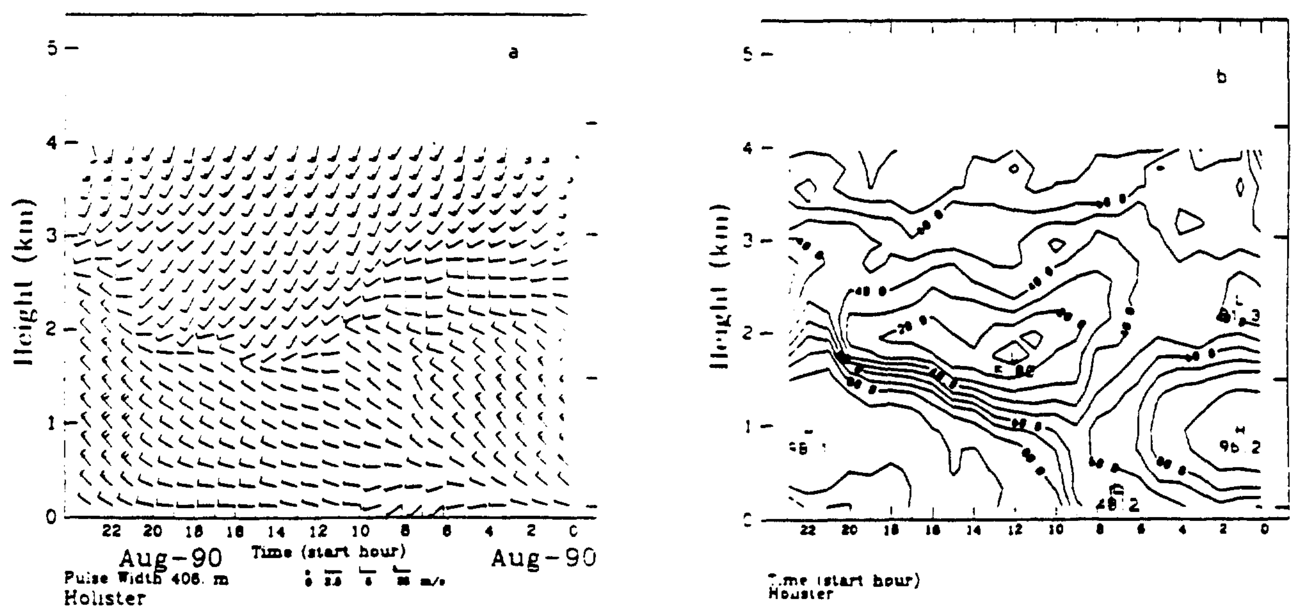

Fig. 5 As in Fig. 2, except for the Hollister profiler data.

feature (Blumenthal et al., 1985), with limited extent along the foothills to the northwest and southeast of Reedley. At Reedley we also note that the interface between northerly and southerly flow only descends to ~2.0 km MSL at noon (as at Corcoran), and that the low-level nocturnal jet remains strong, with a maximum speed of 9.2 m s^{-1} at 22 PDT. The westerly daytime flow present at the other profiler locations is weaker at Reedley, even though it is closer to the Sierra foothills.

Wind data from Hollister (Fig. 5a), which was located outside the San Joaquin Valley to the west of the crest of the Coast Range, show the same general features as the stations along the valley center. However, the daytime flow tends to be more westerly than at stations within the San Joaquin Valley. Persistence values within the low-level nocturnal jet at Hollister show remarkably high values of greater than 95% (Fig. 5b). Surface observations taken at Hollister show a strong decoupling with the flow aloft, with the surface winds being southwesterly during the night and southeasterly during the day, while the profiler winds at 500 m MSL always have a northerly component.

3. TEMPERATURE PROFILES

Thermodynamic profiles were obtained on several days in late August at the Raisin City profiler site. Fig. 6 shows a sequence of 5 temperature profiles taken at approximately one hour intervals during the morning and early afternoon of

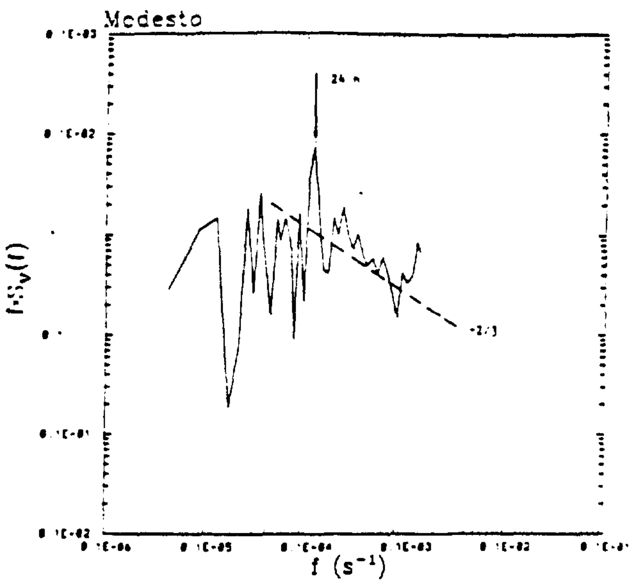

Fig. 9 As in Fig. 8, except at 3.0 km MSL.

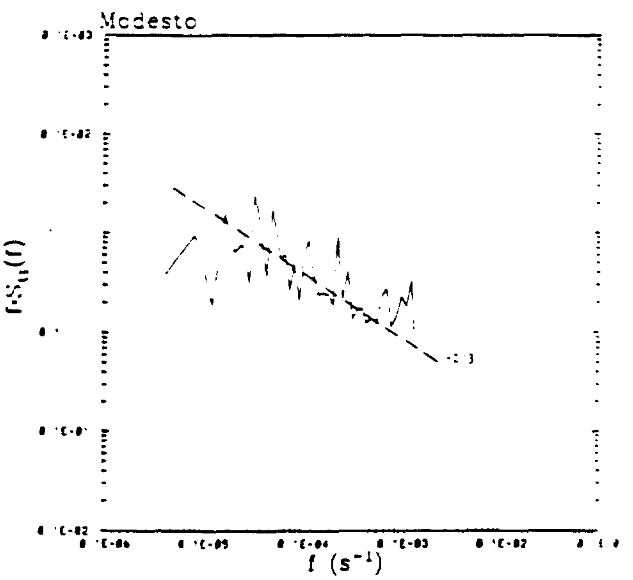

Fig. 10 Cross valley horizontal wind spectra at 3.0 km MSL of the Modesto profiler data.

4. SUMMARY

Wind profiler data have been analyzed for the month of August, 1990, at 7 sites in central California. These data indicate that a nocturnal northwesterly low-level jet is an ubiquitous feature throughout the region, reaching maximum speeds of ~10 m s^{-1} at a height of ~500 m near midnight. Winds within the jet show very little variability, with persistence values higher than 95%. In the daytime convective boundary layer winds are weaker and more westerly, flowing towards the heated slopes of the Sierra Nevadas, and show greater variability. Above, the winds back to southerly flow in a very narrow transition zone that is associated with only a weak change in thermal stratification. The height of the transition zone has a strong diurnal variation, reaching a maximum height of ~3.0 km at midnight, and a minimum height of ~1.5 km at mid-day. This cycle may possibly be attributed to the effect of large-scale convergence and divergence occurring across California resulting from thermally driven onshore (upslope) and offshore (downslope) flows interacting with ambient northwesterly flow. The profiler data also show the frequent development of a mesoscale vortex along the east side of the San Joaquin Valley. Spectra of the profiler winds show a strong diurnal peak, a -2/3 slope consistent with stratified two-dimensional turbulence and saturated gravity-waves, and an increase in energy at high frequencies possibly due to the effects of fully three-dimensional turbulence.

5. ACKNOWLEDGEMENTS

The authors wish to thank the engineering and technical staff of the Atmospheric Studies Program Area of the Wave Propagation Laboratory, whose efforts made this study possible. Partial funding for this research was provided by the San Joaquin Valley Air Quality Study.

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APPENDIX G

THE USE OF 915 MHz WIND PROFILERS IN COMPLEX TERRAIN AND REGIONAL AIR QUALITY STUDIES

By:

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NOAA/ERL Aeronomy Laboratory

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THE USE OF 915 MHZ WIND PROFILERS IN COMPLEX TERRAIN AND REGIONAL AIR QUALITY STUDIES

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1. Introduction

Over the past decade numerous air quality research field programs have made use of upper-air sounding systems including Doppler sodars, radar and optically tracked balloons, and tethered-balloon systems. Unfortunately, Doppler sodars have limited range, usually about 500 m, and provide only a qualitative picture of the stability structure in the boundary layer. Free sondes provide snapshots of wind, stability, and humidity but are limited by cost and their labor-intensive operation. Tethered-balloon systems have been extensively used in short-term field programs but are labor intensive, often restricted in their usefulness in urban areas by stringent rules necessary for aircraft safety, and unable to operate in winds greater than 10 ms^{-1}. On the other hand, new remote sensing technology such as radar wind profilers that operate in the 400 MHz range and infrared Doppler lidar systems, useful as they are for research programs, are limited by their cost for widescale deployment. In addition, lower frequency wind profilers cannot profile closer to the surface than 300 to 400 m. Fortunately, however, Ecklund et al. (1988, 1990) have developed a new low-cost 915 MHz wind profiler designed to continuously profile the lower atmosphere with high resolution. In addition, it has opened up the possibility for simultaneous wind and temperature profiles in the lowest kilometer, a region of great importance to air quality monitoring and research.

During 1990 the Wave Propagation Laboratory (WPL) and Aeronomy Laboratory (AL) of the National Oceanic and Atmospheric Administration joined in the evaluation of the performance of the new 915 MHz profiler in four major air quality studies. Each of the studies represented a vastly different operating environment for the profilers, ranging from wintertime operations in the Grand Canyon of the Colorado (three profilers), to the summertime Pacific coast marine environment (seven profilers), to the humid southeast (one profiler), and finally to the wintertime Colorado Front Range (six profilers).

The profilers used in these studies were copies of the prototype described by Ecklund et al. (1988) but used more rugged construction techniques and computer system for remote, unattended sites. This PC-based radar system was typically installed in a few hours by a two-person crew. Three fixed pointing microstrip antennas were used: a vertical mode with a 2 m^2 (1x2 m) antenna and two oblique 3 m^2 (1x3 m) antennas inclined 15° from the horizontal. Hourly averaged winds were produced using two sounding modes, a short-pulse (60-100 m), short-range (1-2 km) mode and a long-pulse (200-400 m), long-range mode (2-4 km). In the course of the 1990 experiments a number of improvements were made to the system including greater transmitted power, the addition of clutter screens, real-time display of wind speed and direction, telephone-line transmission to a central data hub, and the capability to measure winds beginning 100 m from the surface. Figure 1 shows a typical installation with radar, monostatic sodar, and meteorological tower (near Hollister, California).

2. Demonstration Experiments

Grand Canyon Visibility Study

In the first extensive deployment, three systems were used to study circulation patterns affecting visibility in the Grand Canyon during January, February, and March 1990. One wind profiler operated near Page, Arizona, to characterize transport from the Navajo Generating Station; one, southwest of Page in the vicinity of the Painted Desert; and, a third, in the bottom of the Grand Canyon at Phantom Ranch. All three systems operated throughout the study period with a very low failure rate; maximum altitudes for wind measurements varied from 1 km under dry, very stable conditions to 4 km in situations of moist advection from the southwest. Optically tracked balloon soundings from Page and tethered-balloon soundings from Phantom Ranch provided comparison data for profiler evaluation (Wolfe et al., 1991). In general, data from Page compared well whereas profiler data within the Grand Canyon were occasionally contaminated by scattering from terrain.

Rural Ozone in the Southern Environment (ROSE I)

In a study in rural Alabama during June and July 1990, a single 915 MHz profiler and minisodar were collocated with a comprehensive air chemistry program designed by NOAA's Aeronomy Laboratory to study the role of biogenic emissions in rural ozone formation. The profiler was operated in a single-axis mode following damage from a nearby lightning strike early in the experiment; however, this operation did produce a unique and nearly continuous time series (1-min averages) of vertical velocities and radar reflectivity from which the evolution of the atmospheric boundary layer will be studied (White et al., 1991).

San Joaquin Valley Studies

Short-term observations taken in the San Joaquin Valley over the last decade have suggested a number of complex meteorological phenomena including low-level jets, mesoscale horizontal eddies, mountain-plain circulations, as well as a strong diurnal cycle of coupling and decoupling of atmospheric layers within the first one or two kilometers of the atmosphere above the valley (e.g. Blumenthal et al., 1985). In order to study these circulations in detail and understand and model their impact on pollutant transport and transformation, the San

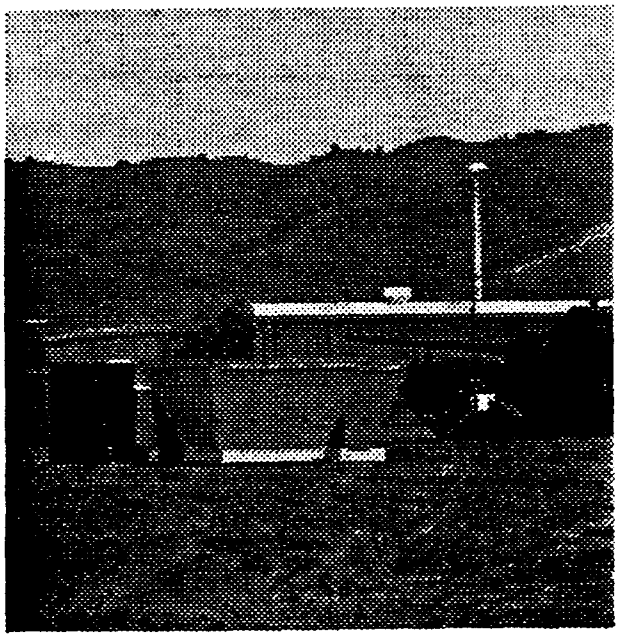

Figure 1. Typical 915-MHz radar wind profiler located at the Hollister California airport. This system was collocated with a monostatic sodar (left) and a surface weather station (right).

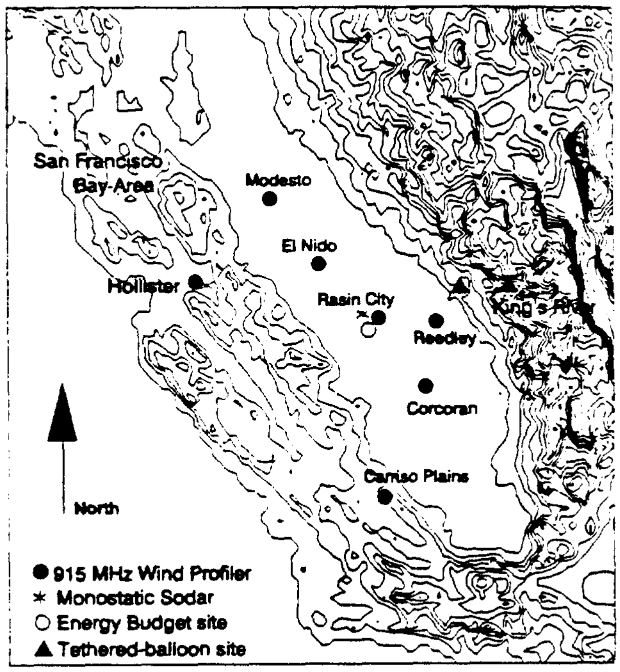

Figure 2. Location of 915-MHz wind profilers in the San Joaquin Valley and coastal areas during July and August 1990. Terrain contour interval is 250 m.

Joaquin Valley Air Quality Study (SJVAQS) and the Atmospheric Utilities Signatures, Predictions, and EXperiments (AUSPEX) field programs provided for one of the most extensive deployments of the 915 MHz wind profilers to date. In these studies, seven profilers were deployed during July and August 1990 (Fig. 2): two to observe marine air penetration over the coastal mountains (Hollister and Carrizo Plains); four along the axis of the valley to observe the southward transport of air masses originating in the San Francisco Bay area (Modesto, El Nido, Raisin City, and Corcoran); and one on the northeastern side of the valley near the foothills of the Sierra Nevada to observe the formation of a region of recirculation called the Fresno Eddy (Reedley). A sonic anemometer was collocated at the Raisin City radar site to measure surface heat and momentum fluxes together with a high-resolution monostatic sodar to observe shallow mixing layers and the initial growth of the convective boundary layer. Because analyses from the Grand Canyon study indicated some contamination from ground clutter, clutter screens (seen in Fig. 1) were designed and deployed at all the profiler sites in this study and proved to be highly effective (Russell and Jordan, 1991).

Front Range Air Quality Studies

Six profilers are currently being deployed along the Colorado Front Range to provide meteorological input for a detailed model validation study [for the U.S. Department of Energy (DOE) Rocky Flats facility], to study large-scale drainage winds [for the DOE Atmospheric Studies in Complex Terrain (ASCOT) program], and to provide a better understanding of the atmospheric circulations responsible for the Denver brown cloud. The profilers in this experiment are being deployed at a variety of sites including one near the Continental Divide; one, near the Rocky Flats facility; two, southwest and northeast of Denver along the South Platte River; and two, on a north-south line east of Denver. Two of the profilers will be equipped with Radio Acoustic Sounding Systems (RASS) to provide continuous temperature measurements. Severe environmental conditions are expected at a number of these sites including strong downslope winds, extreme cold, and heavy upslope snowfall.

3. Observations During the SJVAQS/AUSPEX Study -- Examples

The Low-Level Jet

During typical summertime conditions in the San Joaquin valley, a northwesterly low-level wind has been observed along the axis of the valley. Figure 3 shows a high-resolution (58 m pulse width) wind profiling radar view of this flow on 12 August 1990 at El Nido, a mid-valley site. By 2300 PDT, 12 August 1990, the wind speed maximum has reached 7.5 ms^{-1} at 400 m in this figure. Evident also is the diurnal variation in depth of the strong scattering layer: because of the low average scattered power associated with the 58 m pulse-length mode, its ability to retrieve boundary layer winds is sensitive to boundary layer refractive index gradients, particularly those arising from water

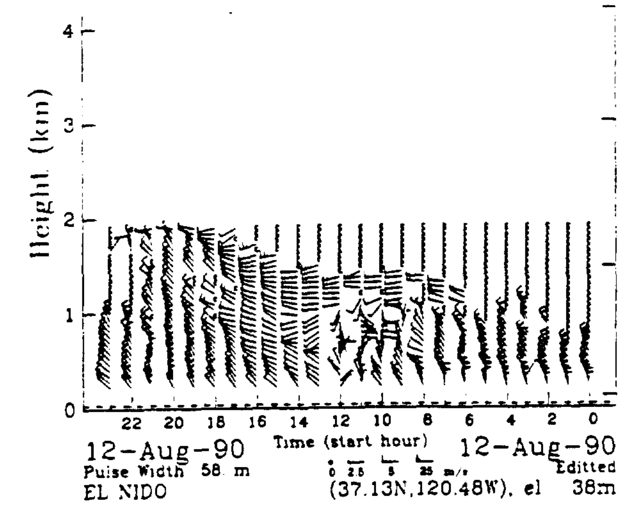

Figure 3. 58-m resolution profiler winds at El Nido, California on 12 August 1990.

vapor variations. Because the low-level jet may be associated with the inflow of moist marine air from the Pacific Ocean through San Francisco, the pattern of scattering in the figure is consistent with the nighttime arrival of moist air, to which the radar is more sensitive. This can also be seen in the wind patterns from 406 m pulse length data on 12 and 13 August 1990 (Fig. 4) where southerly to southwesterly winds overlie the northwesterly inflow into the San Joaquin Valley through El Nido. This figure also indicates regularity of this diurnal pattern as the northwesterly winds begin in late afternoon, increase during the midnight hours, and decrease in the early morning.

The Fresno Eddy

The diurnal pattern of winds associated with the Fresno Eddy can also be seen in the profiler winds measured at Reedley during 12 and 13 August 1990 (Fig. 5). These observations reveal a southeasterly wind developing after midnight each night. These winds, reaching over a kilometer in depth, run parallel to the Sierra Nevada. During the five-day period beginning on 12 August, the eddy became progressively weaker. On the morning of 15 August, northwesterly winds prevailed throughout the region and no eddy developed. As the

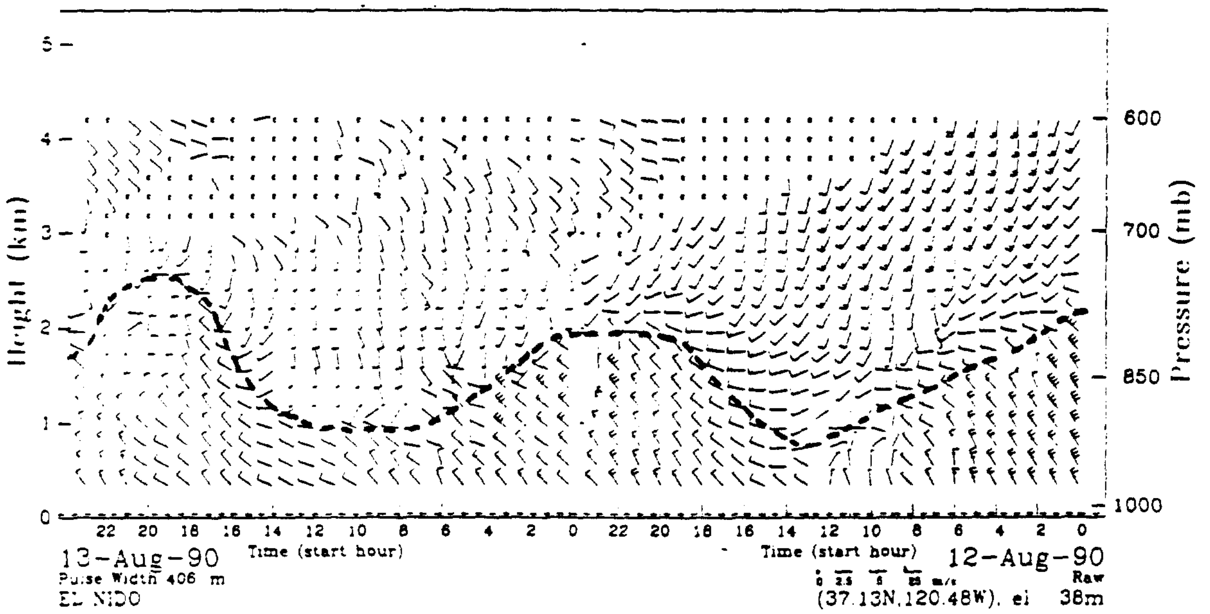

Figure 4. Diurnal variation of winds in the center of the San Joaquin Valley on 12 and 13 August 1990 using 406-m resolution profiler winds. Heavy dashed line marks the upper boundary of the north-to-northwest winds.

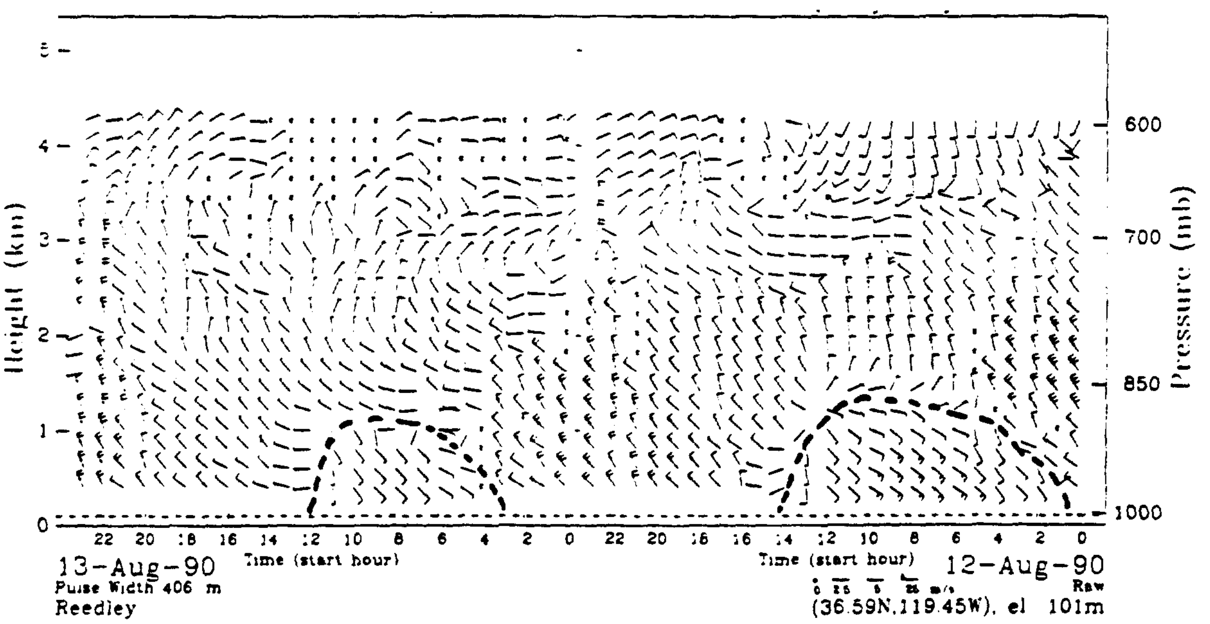

Figure 5. Winds at Reedley, California on 12 and 13 August 1990 using 406-m resolution profiler winds. Heavy dashed line indicates the upper boundary of the southweasterly winds associated with the Fresno Eddy.

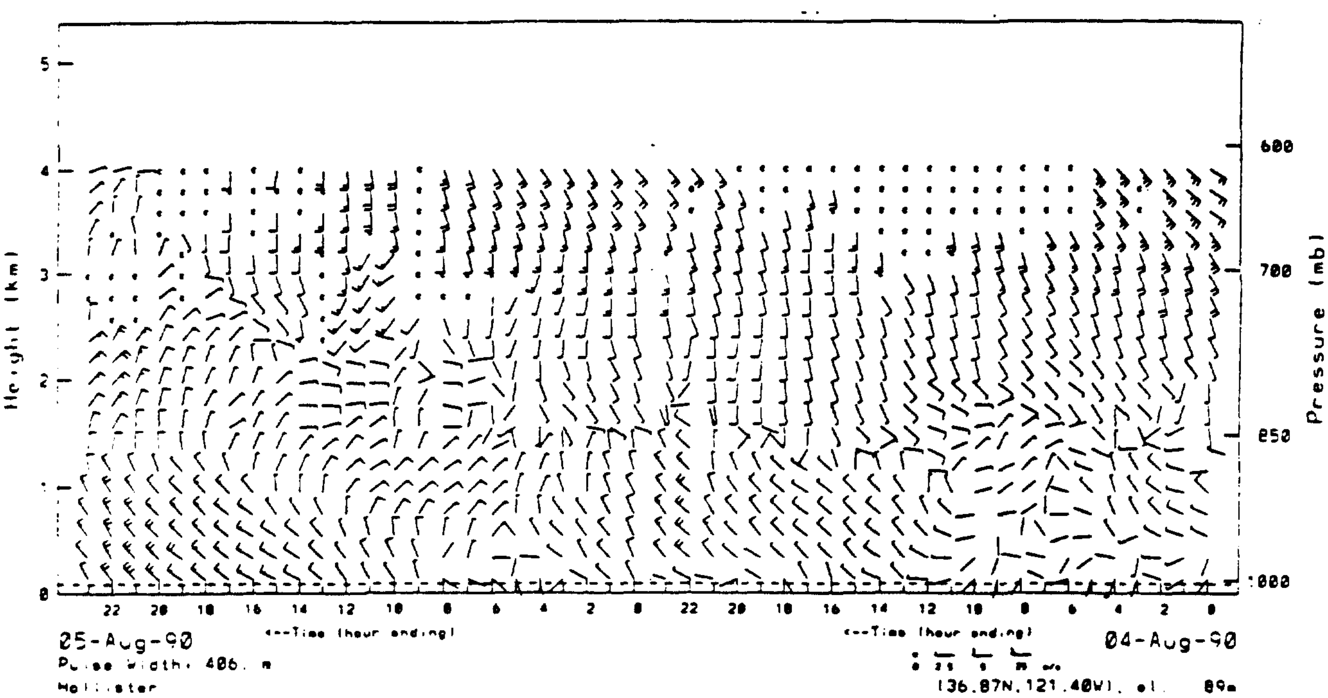

Figure 6. Wind profiler data from Holister, California on 4 and 5 August 1990.

analysis of these data proceeds, use will be made of a large variety of supporting data including surface pressure gradient measurements, Doppler sodar winds obtained at the base of the foothills of the Sierra Nevada, and tethered-balloon soundings taken in the King's River airshed, a 3500 km^2 drainage area east of Fresno, California.

Coastal Circulations

A 915 MHz wind profiler at Hollister, California provided a measurement of winds between the Pacific Ocean and the 500 m to 1000 m high coastal mountains. Observations on 4 and 5 August 1990 (Fig. 6) reveal the afternoon westerly to north-westerly seabreeze underlying persistent upper level southerly winds. These winds begin around noon and end about midnight. There is an indication during the night of 4-5 August that winds at 1000 m ASL rotate inertially as the seabreeze diminishes after midnight. Low-level winds from the south in the early morning period may reflect drainage along the San Benito River airshed.

4. Summary

Portable 915 MHz radar wind profilers have now demonstrated their effectiveness in a broad range of experiments focused on mesoscale air quality problems. They have obtained high-resolution data starting at 100 m AGL within the boundary layer as well as providing coarser resolution wind profiles to heights of 3 to 4 km. They have shown their ability to operate unattended for prolonged periods. A number of improvements are planned in upcoming experiments including the addition of temperature profiling (RASS) and increased antenna size and transmitted power.

Acknowledgements

The authors are indebted to the staff of the Atmospheric Studies Program Area of WPL for the execution of the experiments described in this paper. Of particular note have been the efforts of N. Szczepczynski, S. Abbott, D. Gregg, L. lewis, and J. Leach in the development and construction of the profilers used in the studies. This work was supported in part by the Salt River Project, California Air Resources Board, Pacific Gas and Electric, U.S. Department of Energy (Office of Health and Environmental Research), and the Colorado Department of Health.

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APPENDIX H

ACCOMMODATION OF WIND PROFILER RADARS
U.S. DEPARTMENT OF COMMERCE

By:

Richard D. Parlow,
Associate Administrator,
Office of Spectrum Management,
U.S. Department of Commerce

UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration
Washington, D.C. 20230

December 11, 1991

MEMORANDUM FOR: Executive Secretary, IRAC

FROM: Richard D. Parlow
Associate Administrator
Office of Spectrum Management

SUBJECT: Accommodation of Wind Profiler Radars

Wind profiler radars are designed to provide wind speed and direction as a function of altitude. They can serve as an adjunct to a variety of functions including weather prediction, air pollution research and severe weather warnings. Although wind profilers can operate over a wide range of frequencies, many of the more critical applications require frequencies in the 200-500 MHz range. It is expected that both Government and non-Government entities will use this technology.

To date, the majority of wind profiler radars has been authorized to operate on an experimental basis on the frequency 404.37 MHz. Since these radars point vertically, a number of both national and international groups has expressed concerns about potential interference to the COSPAS/SARSAT satellite uplink frequency in the band 406-406.1 MHz. Several design and operational enhancements have been employed to address this concern, including a feature to automatically inhibit wind profiler transmissions during an overhead pass of the COSPAS and/or SARSAT system. Nonetheless, in the U.S. there have been several reported cases of interference resulting from wind profilers using this feature. Therefore, the protection of a vital safety-of-life service would be placed at risk if development were to continue at 404.37 MHz.

NTIA studied three candidate bands (216-225 MHz, 400.15-406 MHz, and 420-450 MHz) to help determine where in the 200-500 MHz frequency range the wind profiler operations could be accommodated. The results of this study, IRAC Doc. 26985/1, indicate that there is no single frequency currently available on a primary basis to both Government and non-Government users and, as a result, additional spectrum sharing with current users of the bands and a change to the existing National Table of Frequency Allocations are required.

The study of the 216-225 MHz band concluded the frequency 219 MHz (with an authorized bandwidth less than or equal to 2 MHz) could accommodate wind profiler radars in some geographic locations, subject to successful coordination with authorized users of the band and consideration of adjacent TV broadcast operations.

The NTIA study concluded that the 400.15-406 MHz band for long-term wind profiler operations is not suitable, since it would pose an unacceptable risk of interference to the safety-of-life COSPAS/SARSAT satellite system. Because of this threat, the study recommended that existing assignments of wind profiler radars in the 400.15-406 MHz band should be phased out.

The NTIA study concluded that the most suitable band for permanent accommodation of wind profiler radars nationwide is 440-450 MHz and identified two candidate frequencies (441 MHz and 449 MHz for wind profiler operations), each of which has certain advantages and disadvantages.

Currently, the 440-450 MHz frequency band is one-third of the only band below 1000 MHz (i.e., 420-450 MHz) allocated on a primary basis to the Government military radiolocation service. It is used for a number of major military land-based, shipborne, and airborne systems critical to the national defense. These systems perform functions such as the early warning of ballistic missile attack on the United States and long range search and track of potential hostile aircraft. The band is also allocated on a secondary basis to the amateur service. To accommodate Government non-military wind profiler users, a change to the National Table of Frequency Allocations would be necessary.

Subsequent to the completion of the NTIA study, measurements were conducted to determine the impact of various waveforms to the wind profiler from representative radars operating in the 420-450 MHz band. The results of the measurements indicated that low duty cycle radar signals produced no apparent degradation to wind profiler performance.

Of the three candidate bands studied, there is no agreement among the agencies in selecting a frequency for Government wind profiler operations. For example, the DOD agencies oppose considering the 420-450 MHz band since it is the only 30 MHz of contiguous spectrum below 1 GHz that can be used for future radiolocation operations. The Coast Guard opposes the use of the 400.15-406 MHz band for wind profiler operations because it may cause harmful interference to the safety-of-life COSPAS/SARSAT system. For the 216-225 MHz band, some agencies have suggested the band be given more favorable consideration for long term wind profiler operations. However, one DOD agency opposes considering this band since selecting the frequency 219 MHz has a probability of interference to one of the major DOD systems that currently operates in this band. Furthermore, to grant the requirement of primary status for wind profiler operations in this band would be difficult due to RR627 which states that no new radiolocation stations may be authorized after January 1, 1990.

Based on the information available, NTIA concludes that the frequency 449 MHz (with an authorized bandwidth less than or equal to 2 MHz) appears to be the most suitable for wind profiler operations.

Accordingly,

1. NTIA will neither authorize additional Government wind profiler radars nor concur to frequency assignments for new non-Government wind profiler radars that operate in the 400.15-406 MHz band.

2. NTIA will revoke all existing Government wind profiler assignments in the 400.15-406 MHz band on September 30, 1993. Exceptions to this termination will be considered on a case-by-case basis.

3. NTIA will authorize Government wind profiler operations on the frequency 449 MHz. A footnote to accomplish this is as follows:

   GXXX - Government wind profiler radars may be authorized to operate on a primary basis in the radiolocation service on the frequency 449 MHz (with an authorized bandwidth less than or equal to 2 MHz) subject to the following conditions: 1) wind profiler locations must be pre-coordinated with the military services to protect fixed military radars, 2) wind profiler operations will receive no protection from military mobile radiolocation stations, and 3) wind profiler stations will provide protection to military mobile radiolocation stations that are engaged in critical national defense operations.

4. NTIA will implement spectrum standards for Government wind profiler radars operating on the frequency 449 MHz. These standards should be developed by the TSC with an effective date of January 1, 1994.

5. In addition, subject to successful coordination within the Frequency Assignment Subcommittee (FAS), Government wind profiler radars can operate on a non-interference basis on the frequency 219 MHz (with an authorized bandwidth less than or equal to 2 MHz).

APPENDIX I

REQUEST FOR SYSTEMS REVIEW FOR STAGE 3 ASSIGNMENT
U.S. DEPARTMENT OF COMMERCE

By:

S. F. Clifford, Director
Wave Propagation Laboratory
U.S. Department of Commerce

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories
325 Broadway
Boulder, Colorado 80303-3328

October 22, 1991 R/E/WP

MEMORANDUM FOR: Richard Barth
Director, Radio Frequency Management Office

FROM: S. F. Clifford
Director, Wave Propagation Laboratory

SUBJECT: Request for Systems Review for Stage 3 Assignment

Based on your guidance, I have attached a systems review request for the domestic-wide government use of a Stage 3 frequency assignment at 915 MHz for the UHF wind profiler. During extensive nationwide use of fixed and portable wind Profilers operating at 915 MHz over the past ten years there has not been a single observed or reported incident of harmful interference. Clearly, assignment compatibility has been demonstrated with all other users.

With enhanced system development underway, approval of this request in three to six months would be appropriate. When approved the Stage 3 assignment will be for Mr. James R. Jordan acting as my agent for the Wave Propagation Laboratory. Mr. Jordan now holds a domestic-wide Stage 2 frequency assignment at 915 MHz for government use with WPL wind and temperature profilers.

If there are any questions about this request I may be reached on FTS 320-6291. Thank you for your assistance with this request.

Attachments: Request for Systems Review for Stage 3 Frequency Assignment

cc:
R/E/WP7 - W. Neff
R/E/WP7 - J. Jordan
R/E/WP7 - D. Fritz
R/E1 - B. Trotter
R/E1 - T. Maraia
Radian - R. Petersen

(303)
Bert Trotter - 497-3000

REQUEST FOR IRAC/SPECTRUM PLANNING SUBCOMMITTEE REVIEW
for Stage 3 Frequency Assignment for
Telecommunication Systems Intended to Provide
Radiolocation Service for
Wind and Temperature Profiling in the 890-942 MHz band
for the Federal Government

INTRODUCTION:

The Federal Government initiated a wind Profiler radar program in 1981 to experiment with and perfect lower atmosphere wind profiling. The initial frequency request for one of three frequency domains for anticipated weather-related wind Profiler research was in the UHF range at 890-942 MHz. The frequency range assigned in response to a Stage 2 request was at 915 MHz in the ISM band.

Extensive research experience with both fixed and many portable 915 MHz wind Profilers, along with more recent temperature profiling, deriving temperature from the velocity of an acoustic signal, now warrants assignment of spectrum support at Stage 3 for developmental testing of proposed operational hardware and potential equipment configurations.

Temperature profiling critical to meteorological applications in the lower atmosphere using a Radio Acoustic Sounding System (RASS) has a greater height range if the wind Profiler operates at frequencies lower than 400 MHz. However, for the purpose of this Stage 3 request, which will ultimately lead to a Stage 4 request for government operational wind and temperature profiling, frequency assignment at 915 MHz is proposed. The unique, upwards propagation pattern of the UHF wind Profiler warrants this accomodation with present government and non-government allocations to other ground-based users.

BASIS FOR REQUEST:

On July 17, 1979 the IRAC/SPS approved the experimental wind

Profiler radar operations (Stage 2) in the ISM band 902 to 928 MHz in or near Denver, Colorado. Initial on-air transmissions of the 915 MHz wind Profiler constructed at Stapleton International Airport occurred in July 1981. This wind Profiler has been operating essentially continously since then.

During the late 1980's research was conducted on portable wind Profilers. Extensive experience has been gained with these systems operating singly as well as in networks, throughout the

continental U.S. land mass, with the exception of the far northwest region of the country. Attachment 1 details the locations where these portable systems have operated.

Throughout this extensive field observational program, and including the fixed Profiler site at Denver's Stapleton Airport operating with ten times the transmitted power as the portable 915 MHz wind Profiler systems, there has not been a single observed or reported incident of harmful interference.

Beginning in 1987 experimental work was undertaken to explore the usefulness of the wind Profiler in conjunction with an independent, vertically propagating acoustic source (RASS), to profile lower atmosphere temperature. This work has been successful and high resolution temperature profiles can be regularly obtained up to heights of 1-1.5 km with the first temperature measured as low as 90m above the ground using the 915 MHz wind Profiler.

On December 29, 1989 a domestic wide allocation for portable wind Profiler systems was granted to NOAA's Wave Propagation Laboratory. Since then a growing observational demand has been serviced by networks of wind Profilers to observe lower atmosphere wind fields for air quality purposes, including visual obscuration source problems such as in the Grand Canyon (see attachment).

A presently untapped application of UHF wind Profilers is in support of public safety in the airport environment. Aircraft operations for commercial and heavy general aviation are at risk relative to wind shear and turbulence. Networks of wind and temperature Profilers could provide local forecasters with high resolution, frequent observations of wind and temperature which would greatly improve nowcasting for meteorological conditions conducive to dangerous wind phenomena in the airport environment.

Agency No.

FORM NTIA-33 (6-83)

U.S. DEPARTMENT OF COMMERCE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

TRANSMITTER EQUIPMENT CHARACTERISTICS

1. Nomenclature/Model No.: Boundary Layer Profiler Transmitter	1a. Manufacturer's Name
2. System Nomenclature	3. Transmitter Type: pulsed Doppler
4. Tuning Range: 915 MHz	5. Method of Tuning: fixed
6. RF Channeling Capability	7. Frequency Stability: ± 10ppm
8. Emission Designator(s): 6M00P0N	9. Emission Bandwidth for 700 ns pulse ☐ Calculated ☒ Measured -3dB 1.4 MHz -20 dB 40 MHz -40 dB 200 MHz -60 dB N/A Occupied Bandwidth ____ (DOD)
10. Filter employed: ☐ Low Pass ☐ High Pass ☐ Band Pass ☒ None	
11. Maximum Bit Rate: -	12. Maximum Modulation Frequency
13. Pre Emphasis: ☐ Yes ☒ No	14. Deviation Ratio
15. Power (a) Carrier ____ (b) Mean ____ (c) Peak Envelope 500 watts	16. Pulse Characteristics (a) Rate 40,000 to 10,000 (b) Width 400-2800 ns (c) Rise time 50 ns (d) Fall time 50 ns (e) Compression Ratio 10
17. Output Device: solid state	
18. Spurious Level: <-30 db	19. Harmonic Level (a) 2nd -20 db (b) 3rd <-30 db (c) Other none
20. FCC Type Acceptance No.	

21. Remarks:
9. Emission measured for 700 ns pulse width.
16. a) Inter-pulse period is delectable from 25 ns up in 5 ns increments but 25,50, and 100 microseconds are commonly used.
b) One of four pulse widths is selectable. Current available pulse widths are 400, 700, 1400, and 2800 ns.
e) Pulse compression is not currently used, but is planned for future implementation.

Agency No.

FORM NTIA-34 (6-83)

U.S. DEPARTMENT OF COMMERCE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

RECEIVER EQUIPMENT CHARACTERISTICS

1. Nomenclature Model Number: Boundary Layer Profiler Receiver	1a. Manufacturer's Name
2. System Nomenclature	3. Receiver Type: Heterodyne
4. Tuning Range: 915 MHz	5. Method of Tuning: fixed
6. RF Channeling Capability: 915 MHz	7. Frequency Stability: ± 10 pp
8. Emission Designator(s): 6MOOPON	9. RF Selectivity: X Calculated ☐ Measured; (a) -3 dB 33 MHz; (b) -20 dB 40 MHz; (c) -60 dB 16 MHz; (d) Type of preselection used: none
10. IF Selectivity: (a) -3 dB 10 MHz; (b) -20 dB 27 MHz; (c) -60 dB 42 MHz	
11. Maximum Bit Rate: N/A	12. Maximum Post Detection Frequency: 2.5 x MHz
13. De-emphasis Available: ☐ Yes ☐ No	14. Minimum Post Detection Frequency
15. IF Frequency: 60 MHz	16. Sensitivity: (a) -140 dBM dBm; (b) Criteria -15 db SNR; (c) Noise Temperature Noise Figure: 2 Kelvin dB
17. Oscillator Tuned: Above tuned frequency ☐; Below tuned frequency X; Either above or below tuned frequency ☐	
18. Spurious Rejection: 45 db	19. Image Rejection: 45 db

20. Remarks

12. Post detection bandwidth is selectable for four pulse widths. The maximum post detection frequency is determined by the matched filter for the 400 ns pulse width.

Agency No ______________

NTIA 35 | U.S. DEPARTMENT OF COMMERCE

ANTENNA EQUIPMENT CHARACTERISTICS

1. Nomenclature Model Number: Boundary Layer Profiler Antenna	1a. Manufacturer's Name:
2. System Nomenclature:	3. Type: micro strip phased array 1 x 3 meters
4. Frequency Range: 10 MHz	5. Polarization: vertical
6. Gain (a) Main Beam: 26 db (b) Side Lobe: 13 @ 15°	7. Scan Characteristics (a) Type: fixed pointing angles (b) Vertical Scan (1) Max. Elev. ___ (2) Min. Elev. ___ (3) Scan Rate ___ (c) Horizontal Scan (1) Sector Scanned ___ (2) Scan rate ___
8. Beamwidth (a) Horizontal: 20° (b) Vertical: 6°	

9. Remarks

3. Three separate antennas are used for wind profiling. Two antennas pointing 15 degrees from the vertical aimed in orthogonal azimuths and one pointing vertically. Antennas are built from 1 meter square panels into various configurations. The orthogonal antennas currently in use are 3 by 1 meters giving a 6 by 20 degree beamwidth. The vertical antenna is either 1 by 2 meters for a 20 by 10 degree beamwidth or 2 by 2 meters resulting in a 10 by 10 degree beamwidth. An electrically steerable phased array is under development that will be 3 by 3 meters with a circular beamwidth of 6 degrees.

6. Gain and side lobe levels is given for a 2 by 2 meter antenna. Ground clutter fences are used to block any side love energy to 20 degree above the horizon.

(Last page in Chapter 10)

UHF PROFILER FIELD OBSERVATIONS
Conducted by or in Collaboration With
The Wave Propagation Laboratory

Lake Erie, New York	Single instrument Jan. - Mar. 1990	Lake effect storms
Grand Canyon SALT River Program	3 Profilers Jan. - Mar. 1990	Obscuration source study
Pt. Barrow, Alaska	Single instrument March 1990	Arctic Leads exp.
Ft. Huachuca, New Mexico Aerostat site	Single instrument Sept.-Oct, 1990	Met. support for launch/recovery
Carpenter, Wyoming	Single instrument Sept.-Oct. 1990	Boundary layer research
Alabama	Single instrument June-August 1990	Rural Ozone
San Joaquin Valley	7 instruments July-August 1990	Ozone/air flow
Northwest of Denver	6 Profilers Jan. - Apr. 1991	Front Range air quality study
Deadhorse, Alaska	Single instr. April 1991	Arctic Leads exp.
Lake Michigan	7 Profilers June-Aug. 1991	Lake Michigan Ozone Study
Boston, Mass. Cape Race, Newfoundland	2 Profilers June-Sept 1991	North Atlantic Regional experiment
San Joaquin Valley	8 Profilers May-October 1991	California Transport Study

APPENDIX J

WIND PROFILERS: APPLICATIONS AND CHARACTERISTICS

By:

Daniel C. Law,
National Oceanic and Atmospheric Administration,
Forecast Systems Laboratory

Wind Profilers: Applications and Characteristics

In our second "insider's look" at wind profiler radars, we'll examine the functions and characteristics of the high-tech forecasting tools that will soon share the band at 449 MHz.

By Daniel C. Law
National Oceanic and Atmospheric Administration
Forecast Systems Laboratory
Boulder, CO 80303

Government wind profiler radar systems have been authorized to use 449 MHz, a frequency already used by amateur repeaters in many parts of the country.

In a sequence of two invited articles, NOAA engineers give us an inside look at how wind profilers work, how the decision was made to put them at 449 MHz and what impact, if any, they'll have on Amateur Radio.

This month's article was written by Daniel C. Law, an engineer with NOAA's Forecast Systems Laboratory in Boulder, Colorado.

A companion article ("Wind Profiler Frequencies," April 1992 QST, pages 22-24) was written by Richard Barth, W3HWN, who heads the Office of Radio Frequency Management for the US Department of Commerce.

In 1985, the Environmental Research Laboratories of the National Oceanic and Atmospheric Administration initiated the Wind Profiler Demonstration Project, a plan to install and operate a network of 30 wind profilers in the central US. The purpose of the project is to assess the impact of commercially produced wind profilers on National Weather Service operations. The installation of the profilers at the sites shown in Fig 1 is now complete.

Development and Applications

Wind profilers are vertically directed Doppler radars that trace their lineage to ionospheric and meteorologic research radars. As these radars became more sophisticated, operators began getting radar reflections from regions lacking known "scatterers" such as water, ice, birds and insects. There was a lot of speculation as to the source of these "pixies" or "ghosts," and it was soon verified that radars of sufficient sensitivity could detect backscattered signals from irregularities produced by variations in air temperature and humidity. For this reason, profilers are often referred to as "clear-air" Doppler radars.

NOAA's Demonstration Network profilers operate with an experimental authorization at 404.37 MHz (74.2 cm) in the Meteorological Aids band. This frequency was selected as a compromise between considerations such as altitude coverage, antenna size, system costs and bandwidth availability. The National Telecommunications and Information Administration (NTIA) has recently ruled that future profilers will operate at 449 MHz and that present experimental operations will be phased out.

Data from each profiler is sent every six minutes to a computer in the Profiler Control Center in Boulder, Colorado. Hourly wind measurements are sent in near real-time to the National Weather Service Forecast Offices. In addition, the data is used in numerical models where it is combined with data from balloon, satellite and air-

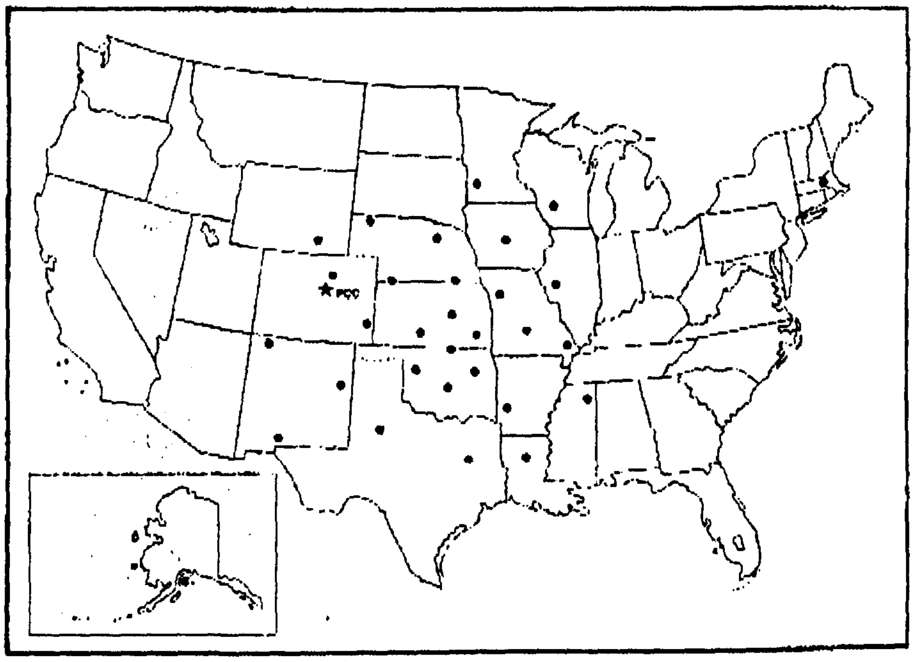

Fig 1—As part of NOAA's Wind Profiler Demonstration Project, these sites host operational wind profiler radars. When completed, 30 sites will be on-line.